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DISPERSED CUTICULAR FLORAS OF SOUTH AUSTRALIAN TERTIARY COALFIELDS, PART 2: LOCHIEL

by A. I. ROWETT*

Summary

ROWETT, A. I. (1992) The dispersed cuticular floras of South Australian Tertiary Coalfields. Part 2. Lochiel. *Trans. R. Soc. S. Aust.* **116**(3), 95-107, 30 November, 1992.

Dispersed cuticles were recovered from two lithotypes (Facies Ia, IIa) within the G seam of the Kooliata Coal Zone of the Lochiel Coalfield. The floras are distinct. The younger lithotype (IIa) contains a monospecific flora, represented by a robust, coriaceous non-stomatiferous cuticle whereas the older lithotype (Ia) contains thirty-seven cuticle types. The major contributors are *Agathis* (Araucariaceae) which dominates the flora and Podocarpaceae, Proteaceae and Myrtaceae.

KEY WORDS. Palaeobotany, Tertiary, Eocene, dispersed cuticles, Lochiel, South Australia.

Introduction

This is the second paper on the dispersed cuticular floras of South Australian Tertiary coalfields and follows the format used in Rowett (1991).

The Lochiel coalfield, located 130 km north of Adelaide (Fig. 1), at the head of the Gulf St Vincent (33°56', 138°10'), is one of five separate lignite deposits within the Northern St Vincent Basin, i.e. the Beaufort, Bowmans, Clinton and Whitwarta deposits. It was first discovered in 1982 by geologists of the Electricity Trust of South Australia.

The Northern St Vincent Basin is characterised by north-south trending faults, considered responsible for controlling Tertiary sedimentation (South Australian Department of Mines and Energy 1987). The Ardrossan and Whitwarta Faults (Fig. 1) delineate the Lochiel deposit in the west and east.

The Lochiel coal-bearing sediments are members of the Clinton Formation which has been subdivided into three units in the northernmost part of the basin, from the base, the Bumbunga Sands, Condowie Silt and Kooliata Coal Zone (ETSA 1988[1]). Small lignite lenses occur in the Bumbunga Sands but are of little economic importance. Three major lignite seams (F, G and H seams) occur in the Kooliata Coal Zone (Kremor & Springbett 1992), which average thicknesses of 2, 6.5 and 2.5 metres respectively. Carbonaceous lacustrine silt, sand and clay of the Condowie Silt separate the Bumbunga lignites from those of the Kooliata Coal Zone. Unconsolidated Oligocene clay, silt and water-saturated sand of the Warrindi and Tarella Silts, ranging in thickness from 20-70 m, unconformably overlie the lignite.

Palynological evidence from these lignites suggests a Late Eocene-Oligocene age (Harris 1965, 1971; Alley & Lindsay 1991 pers. comm.). The palynoflora from the Bumbunga lignite are the time equivalents of the Middle and Upper *Nothofagidites asperus* Zones of Stover & Partridge (1973, 1983), which are Late Eocene to Early Oligocene in age (Kremor & Springbett 1992). The Kooliata lignite is somewhat younger, probably Early Oligocene, and the palynofloras are time equivalent to the Lower *Proteacidites tuberculatus* Zone (Stover & Partridge 1973, 1983).

Materials and Methods

Lignite samples were recovered from a trial pit (Fig. 1) excavated during the initial resource assessment in 1987. Only the lignite seams of the Kooliata Coal Zone were exposed in the pit (Springbett pers. comm.) but limited access (1 hour) to University of Adelaide, Botany Department collectors prevented comprehensive sampling. Sampling was therefore undertaken of those lignite seams noted to contain considerable amounts of heavily carbonised dispersed cuticle and wood fragments. The two samples selected for this study were taken from Facies Ia and IIa of the central G seam (Springbett pers. comm; Fig. 2).

Dispersed cuticles of the Lochiel deposit were processed and analysed using techniques outlined by Christophel *et al.* (1987), Rowett & Christophel (1990) and Rowett (1991).

Dispersed Cuticle Flora

Analysis of samples revealed a diverse cuticular flora of 38 parataxa which are unevenly represented in the two facies, i.e. 1 (Facies IIa), 38 (Facies Ia).

The cuticle flora of the upper highly gelified lignite (IIa) consists solely of the parataxon No. AW 007, which is very distinctive despite the absence of stomates. The robust, thick, coriaceous cuticle, sinuous

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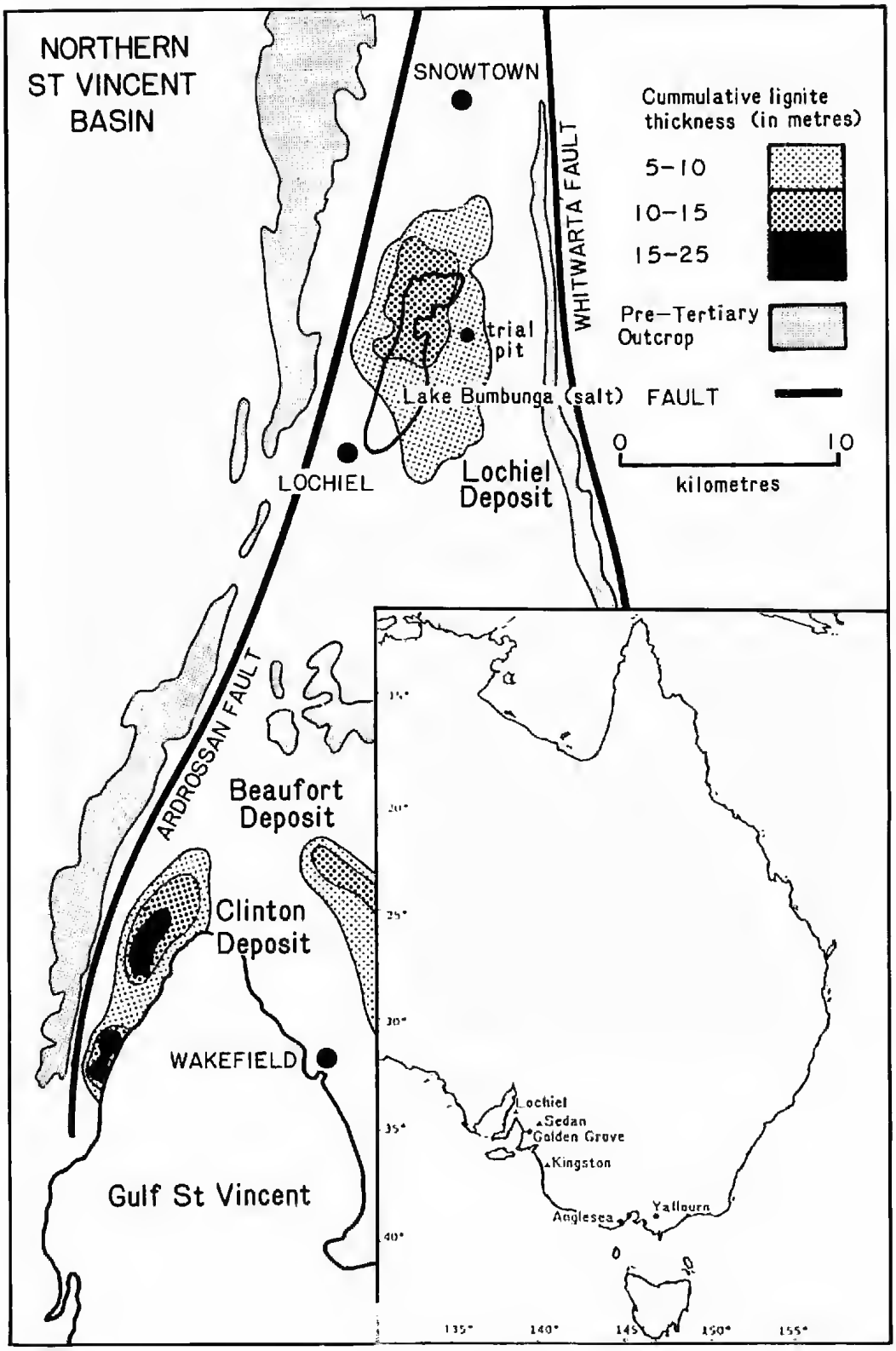
[1] Figure on page 5 of ETSA 1988, Lochiel report shows E-W stratigraphic cross-section of deposit.


NORTHERN
ST VINCENT
BASIN
SNOWTOWN
WHITWARTA FAULT
Cummulative lignite
thickness (in metres)
5–10
10–15
15–25
Pre–Tertiary
Outcrop
FAULT
0
10
kilometres
trial
pit
Lake Bumbunga (salt)
LOCHIEL
Lochiel
Deposit
ARDROSSAN FAULT
Beaufort
Deposit
Clinton
Deposit
WAKEFIELD
Gulf St Vincent
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Sedan
Golden Grove
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135°
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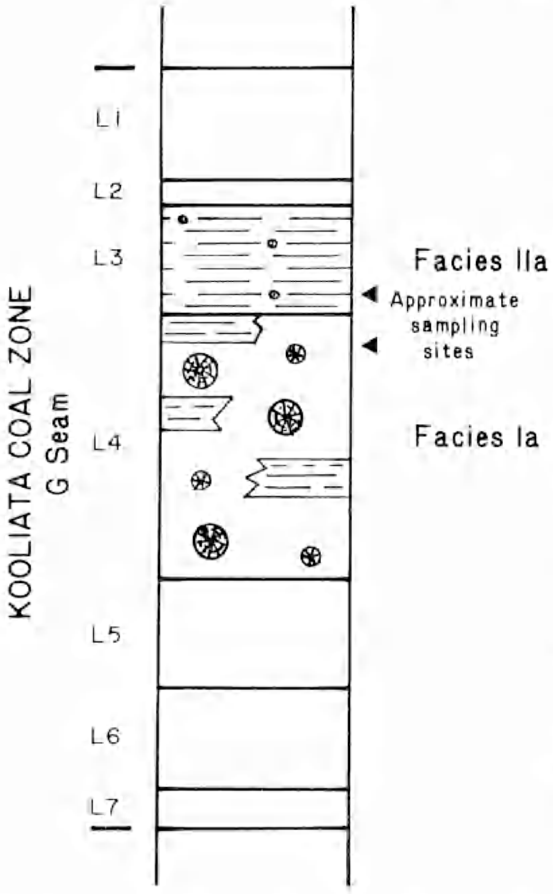


Fig. 2. A simplified lithological column of G seam of the Kooliata Coal Zone showing the seven lenses identified by Springbett (L1-L7) and the approximate location of the samples used in this investigation within Facies Ia and IIa. Facies Ia is an earthy textured coal containing more than 40% relatively ungelified woody material while Facies IIa is a darker fibrous, lignite consisting of gelified twigs. The seam is approximately 6.5 m thick and at a depth of 30 metres.

epidermal cells (types 3 -4 of Wilkinson 1979) and distinctive trichome clusters distinguish this cuticle from all stomatiferous parataxa (Fig. 3). This monospecific flora may provide a useful stratigraphic marker in the correlation of the Lochiel lignites. Parataxon No. AW 007 is also present in the underlying facies (Facies Ia).

The lower lignite facies, with an abundance of wood ranging from twigs to large diameter logs, contains a dispersed cuticle flora characterised by a large Araucariaceae component (29.0%) as well as significant Podocarpaceae (15.5%), Myrtaceae (15.2%) and Proteaceae (12.9%) components (Table 1). Unknown cuticle types represent a large percentage of the Lochiel flora (33.5%). Casuarinaceae, Elaeocarpaceae, Lauraceae and Zamiaceae are poorly represented (0.5%, 0.6%, 0.4% and 0.2% respectively).

The Araucariaceae is represented by a single parataxon No. LC 003 (Figs 4-5) with a suggested affinity to the modern *Agathis*. The fragmentary cuticles, a common feature of this locality, makes a more definite identification impossible.

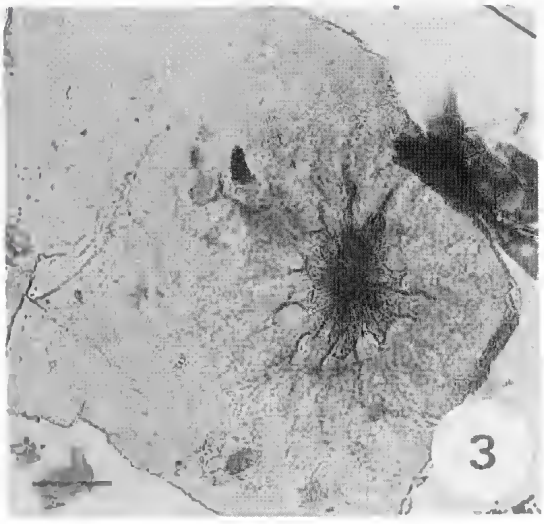
The Podocarpaceae is represented by three parataxa of which No. LC 002 (9.9%) is most abundant (Figs 6-7). Stomates have a variable appearance which makes it difficult to assign the cuticle type to a known podocarp genus. The circular appearance of numerous stomates suggests a possible affinity to *Falcatifolium* (Greenwood 1987). Parataxa Nos. LC 015 and ABP 001 are also common, representing 4.6% and 1.0% respectively. Parataxon No. LC 015 is assigned to *Dacrycarpus* on the basis of smooth-walled epidermal cells and arrangement and cuticular thickening of subsidiary cells (Figs 8-9). Parataxon No. ABP 001 (Figs 10-11) is identified as the cuticle of *Podocarpus platyphyllum* (Greenwood 1987).

The Myrtaceae comprises two cuticle types Nos. LC 001 (12.0%) and LC 011 (3.2%). Both appear

TABLE 1. *The cuticle frequencies (%) of extant plant families represented in the two facies of the central lignite seam of the Lochiel deposit.* Families represented are Podocarpaceae (POD), Araucariaceae (ARAUC), Myrtaceae (MYRT), Elaeocarpaceae (ELAEO), Proteaceae (PROT), Lauraceae (LAUR), Casuarinaceae (CAS), Zamiaceae (ZAM). The OTHERS category represents all other cuticle parataxa whose modern family affinities are unknown.

LOCALITY	POD	ARAUC	MYRT	ELAEO	PROT	LAUR	CAS	ZAM	OTHERS
Lochiel (Facies Ia)	15.5	29.0	15.2	0.6	12.9	0.4	0.5	0.2	25.7
Lochiel (Facies IIa)	–	–	–	–	–	–	–	–	100.0

Fig. 1. Map showing extent and thickness of lignite in the Lochiel deposit and major structural features. Inset: Map of eastern Australia showing the location of the Sedan, Lochiel and Kingston coal localities relative to the Tertiary megafossil localities of Golden Grove (Eocene), Anglesea (Eocene) and Yallourn (Oligocene).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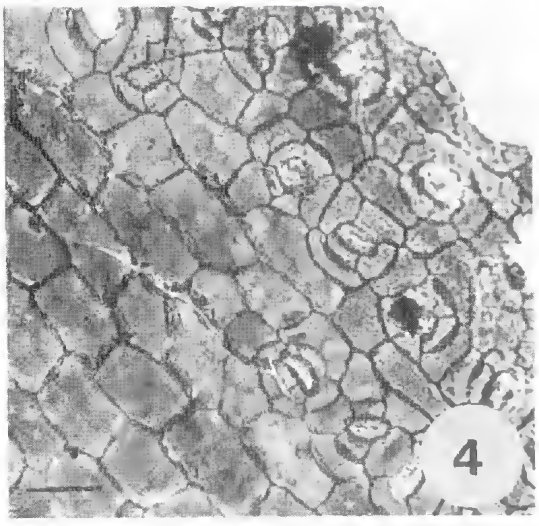
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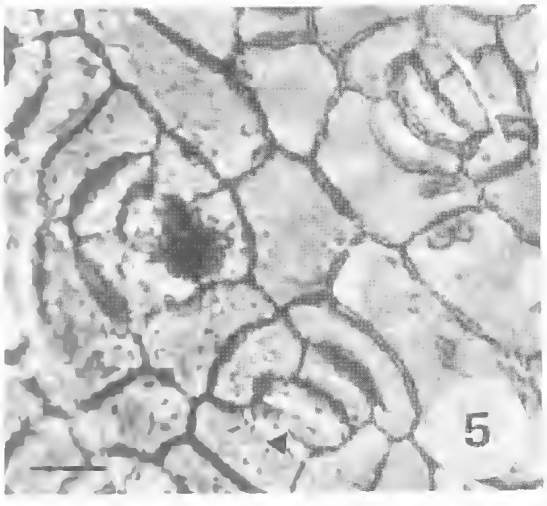
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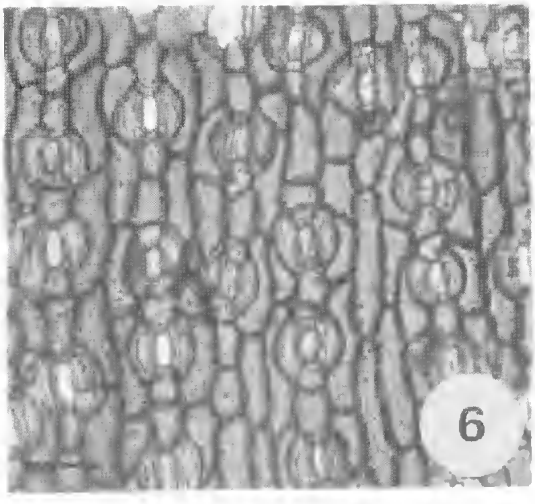
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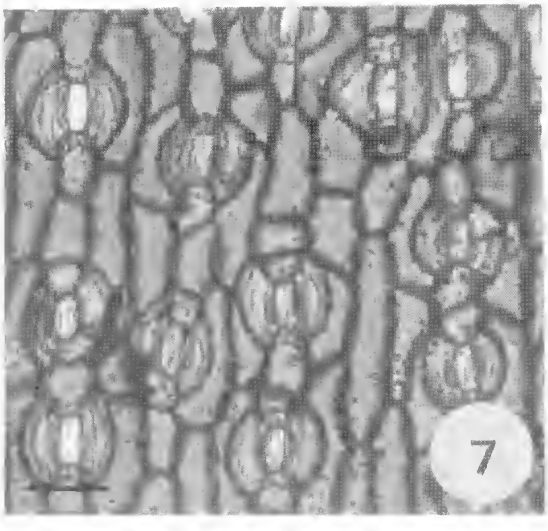
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morphologically similar but can be distinguished on epidermal cell shape, stomatal arrangement and epidermal cell, stomate and oil gland lid cell dimensions. Parataxon No. LC 001 (Figs 12-13) is characterised by rounded to undulate epidermal cells, an anisocytic to staurocytic stomatal arrangement of 3-5 subsidiary cells and lid cells that may be constricted at the sinus. Parataxon No. LC 011 on the other hand, is characterised by undulate to sinuous epidermal cells, a (cyclocytic to) staurocytic stomatal arrangement of 3-6 dark-staining subsidiary cells and large lid cells not constricted at the sinus (Rowett 1991). None of these parataxa are closely comparable with cuticles of the species of *Myrtaciphyllum* described by Christophel & Lys (1986) from Anglesea.

The Proteaceae is a diverse group of nine cuticle types the majority occurring in low frequencies (>0.1%). The most abundant is *Banksieaephyllum* aff. *B. laeve* (5.1%), the same cuticle type that dominated the Late Eocene lignites of the Sedan deposit (Rowett 1991). Two other common cuticle types are parataxa Nos. LC 004 (3.0%) and LC 012 (2.8%), both assigned to *Banksieaephyllum* with the former cuticle type identified as *Banksieaephyllum* aff. *B. fastigatum* Cookson & Duigan (Figs 14-15). The cuticle can be identified by the well-defined areoles, the relatively low frequency of stomata/areole, slightly raised stomata, a pair of poorly defined subsidiary cells surrounded by 3-5 darkly stained epidermal cells and long unicellular trichomes with a poral base. The cuticle of *B. fastigatum* was described by Cookson & Duigan (1950) from the Oligocene brown coals of Yallourn together with five other species of *Banksieaephyllum*, i.e. *B. angustum*, *B. acuminatum*, *B. laeve*, *B. pinnatum* and *B. fastigatum*. The distribution of these species has been discussed by Rowett (1991).

Parataxon No. LC 012 may have an affinity to *B. obovatum* Cookson & Duigan (Figs 16-17). Descriptions of *B. obovatum* and *B. fastigatum* are similar, the distinguishing feature appears to be position of the stomate, i.e. slightly raised in the former and slightly sunken in the latter (Cookson & Duigan 1950). Another cuticle type, parataxon No. LC 013 (Fig. 18), is also assigned to *Banksieaephyllum*. It is possible the parataxon may represent another fragment of *Banksieaephyllum* aff. *?B. obovatum*.

Casuarinaceae, Elaeocarpaceae, Lauraceae and Zamiaceae are of minor importance in the lower Lochiel flora. Casuarinaceae is represented by *Gymnostoma* (parataxon No. DM 007), which also occurs in the lower lignite seam of the Sedan deposit (Rowett 1991). *Gymnostoma* cuticles at Lochiel indicate that the genus was more widespread during the Late Eocene-Early Oligocene, not restricted to south-eastern Australia as would appear was the case during the Middle Eocene (Christophel 1980; Rowett & Christophel 1990).

Zamiaceae is represented by parataxon No. ABD 002 identified as *Pterostoma* aff. *?P. zamioides* Hill (1980) (Figs 19-20). This tentative association is prompted by the rarity and poor preservation of the Lochiel specimens.

Elaeocarpaceae and Lauraceae are represented by cuticle types ABD 005 and AG 010 (Figs 21-22 and Figs 23-24 respectively).

Dispersed Cuticle Descriptions

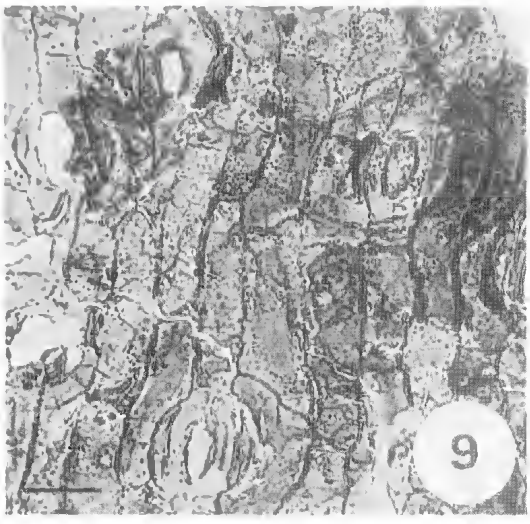
As in Rowett (1991) only parataxa of floristic, stratigraphic and taxonomic significance are described. Some parataxa have been previously identified by the author from other Eocene localities (Rowett & Christophel 1990; Rowett 1991). These and many more are included in the National Energy Research Development and Demonstration Council reference cuticle catalogue of Australian Eocene cuticles types (Rowett in prep[2]). All parataxon numbers are preceded by an abbreviation of the type locality. Terminology used in these descriptions follows that of Rowett (1991) which was derived from Stace (1965), Dilcher (1974) and Wilkinson (1979).

Cuticle Parataxon No. AW 007
FIG 3

Thick, coriaceous cuticle. Non-stomatiferous surface only. Adaxial epidermal cells undulate (type 3-4,

[2] Australian Eocene Dispersed Cuticle Catalogue. Appendix A to ROWETT, A. I. (1990). National Energy Research Development and Demonstration Council, Final Report, No. 3.

Figs 3-8. 3, Parataxon No. AW 007. Non-stomatiferous cuticle of unknown affinity. Note heavy cuticular thickening around the trichome base. Scale 1 cm = 70 μm. 4, Parataxon No. LC 003, aff. *Agathis*, Araucariaceae. Shows predominantly obliquely oriented stomates arranged in rows and rounded epidermal cells. Scale 1 cm = 45 μm. 5, Parataxon No. LC 003, aff. *Agathis*, Araucariaceae. Cuticular thickening around stomatal pore could be interpreted as a Florin ring (arrowed). Scale 1 cm = 22 μm. 6, Parataxon No. LC 002, *?Falcatifolium*, Podocarpaceae. Shows arrangement of stomates in broad bands consisting of long uniseriate rows. Scale 1 cm = 50 μm. 7, Parataxon No. LC 002, *?Falcatifolium*, Podocarpaceae. Shows stomatal arrangement and a number of circular stomates, which may suggest an affinity to this genus. Scale 1 cm = 40 μm. 8, Parataxon No. LC 015, *Dacrycarpus*, Podocarpaceae. Shows arrangement of stomates. Scale 1 cm = 50 μm.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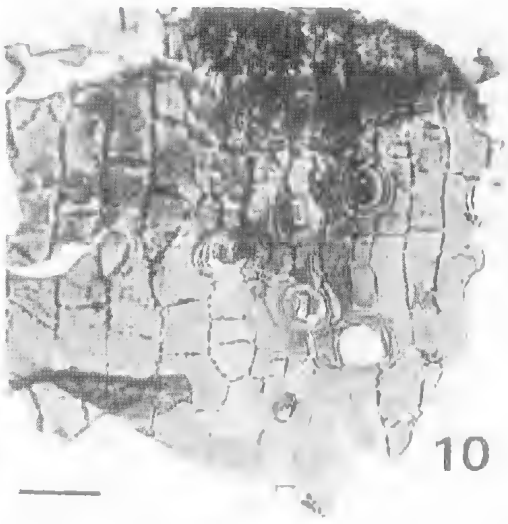
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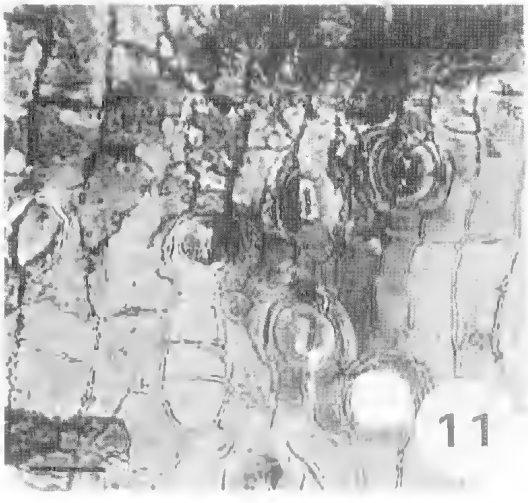
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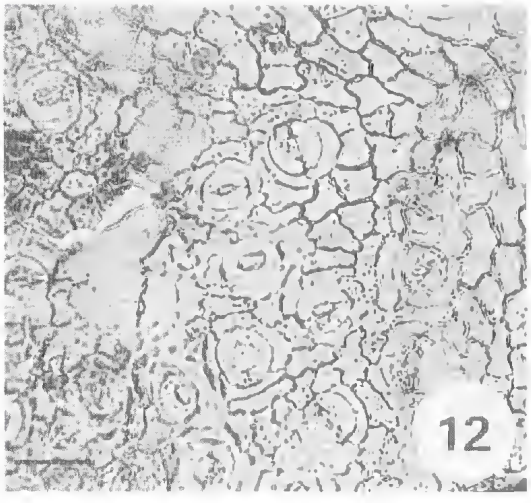
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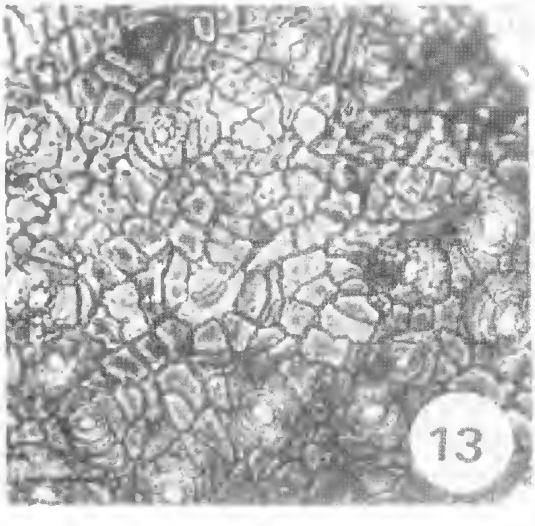
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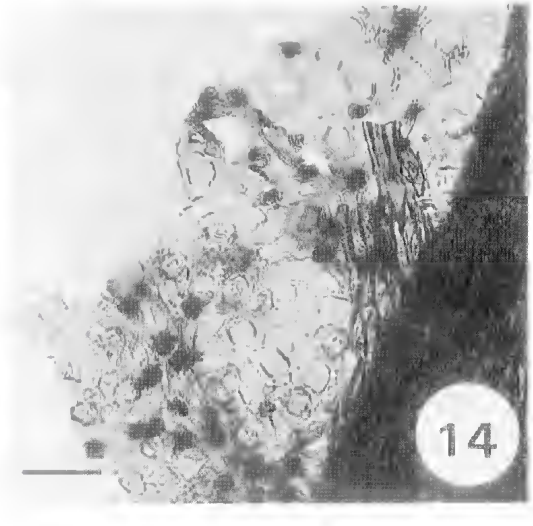
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Wilkinson, 1979). 48-80μm long, 40-68μm wide. Anticlinal wall thin, smooth. Periclinal wall irregularly thickened, granulate to striate. Trichome bases multicellular?, common, uniform distribution, give rise to many single cell trichomes, appear as tufts. Trichomes of variable length, radiate out from centre of base.

Affinity: Unknown.

Cuticle Parataxon No. LC 003
FIGS 4-5

Stomatiferous surface only. Epidermal cells angular to rounded, arranged in longitudinal rows, 24-44μm long, 20-36μm wide. Anticlinal wall irregularly thickened, smooth to beaded. Periclinal wall granulate. Stomata loosely arranged in uniseriate rows, 20-32μm long, 8-16μm wide. Stomatal orientation ranges from parallel, oblique to perpendicular to long axis of epidermal cell rows. Stomatal arrangement tetracytic to cyclocytic. Guard cells sunken. Subsidiary cells 4-5, lateral cells generally larger than polar cells. Anticlinal wall smooth to beaded. Periclinal wall granulate. Guard cell/subsidiary cell wall heavily cutinized, slightly raised. Florin ring evident.

Affinity: The parataxon is assigned to the Araucariaceae. The predominantly oblique orientation of stomata, rounded epidermal cells and uniseriate stomatal rows suggest an affinity with *Agathis* (Cookson & Duigan 1951; Stockey & Taylor 1981; Bigwood & Hill 1985; Hill & Bigwood 1987).

Cuticle Parataxon No. LC 002
FIGS 6-7

Stomatiferous surface only. Epidermal cells angular, arranged in longitudinal rows oriented parallel to vein direction, 32-60μm long, 8-28μm wide. Anticlinal wall irregularly thickened, smooth be beaded. Periclinal wall irregularly thickened, smooth to granulate to pitted. Stomata arranged in uniseriate rows, may be discontinuous, oriented parallel to vein direction, rows grouped in broad bands, 2-4 epidermal cells apart. Stomatal arrangement tetracytic. Guard cells sunken, polar thickening. Outer stomatal ledge, prominent, broad. Florin ring present. Subsidiary cells four (rarely five), polar cells wedge-shaped to rounded (occasionally elongate) rarely shared, lateral cells crescent-shaped. Anticlinal wall irregularly thickened, smooth to beaded, thickening extends along radial walls of polar cells. Periclinal wall irregularly thickened, smooth to granulate.

Affinity: The parataxon is assigned to the Podocarpaceae with a possible affinity to *falcatifolium* but may equally belong to one of the many extinct Australian Tertiary genera.

Cuticle Parataxon No. LC 015
FIGS 8-9

Stomatiferous surface only. Epidermal cells generally rectangular. Cells 25-125μm long, 12.5-27.5μm wide. Anticlinal wall undulate, smooth or showing some buttressed thickening. Periclinal wall irregularly thickened, granulate to striate. Stomata in broad bands, oriented parallel to the long axis of the leaf. Stomatal bands contain on average six uniseriate rows of stomata. Stomata generally separated by more than a single epidermal cell. Stomatal arrangement paratetracytic. Guard cells slightly sunken. Subsidiary cells four (rarely five). Polar cells much smaller than lateral cells. Lateral cells arched. Anticlinal wall rounded, smooth to beaded thickening, occasionally buttressed. Periclinal wall very thick, darker staining. Thickening extends over guard cells. Stomatal ledge evident.

Affinity: The parataxon is assigned to *Dacrycarpus* (Podocarpaceae). Distinguishing features of this cuticle mainly are related to subsidiary cells, i.e. shared polar subsidiary cells, thicker cuticle over the polar subsidiary cells and lateral subsidiary cells that surround the base of the polar subsidiary cells.

Cuticle Parataxon No. ABP 001
FIGS 10-11

Stomatiferous surface only. Epidermal cells rectangular to isodiametric between stomatal rows, becoming elongate over veins, oriented parallel to long axis of the leaf, some groups of cells obliquely oriented to

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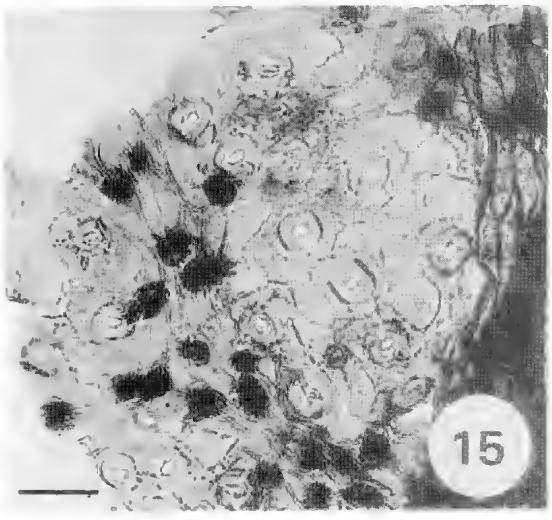
Figs 9-14. 9, Parataxon No. LC 015, *Dacrycarpus*, Podocarpaceae. Shows elongate polar subsidiary cells and increased thickening of the lateral subsidiary cells within the stomatal arrangement. Scale 1 cm = 37 μm. 10, Parataxon No. ABP 001, *Podocarpus* aff. *P. platyphyllum*, Podocarpaceae. Shows arrangement of stomates in short uniseriate rows. Note beaded thickening on anticlinal walls of epidermal cells and the presence of striations on polar subsidiary cells. Scale 1 cm = 55 μm. 11, Parataxon No. ABP 001, *Podocarpus* aff. *P. platyphyllum*, Podocarpaceae. Shows stomatal arrangement. Note prominent Florin ring surrounding stomate (arrowed). Scale 1 cm = 35 μm. 12, Parataxon No. LC 001, Myrtaceae. Shows sinuous epidermal cells and random arrangement of stomates. Note prominent guard cells and associated T-shaped thickening at the poles. Scale 1 cm = 40 μm. 13, Parataxon No. LC 001, Myrtaceae. Shows an oil gland lid cell (lc), a diagnostic cuticular feature of the family. Scale 1 cm = 40 μm. 14, Parataxon No. LC 004, *Banksiaephyllum* aff. *B. fastigatum*, Proteaceae. Shows small clusters of sunken stomates between prominent veins covered with numerous dark-staining hair bases. Scale 1 cm = 80 μm.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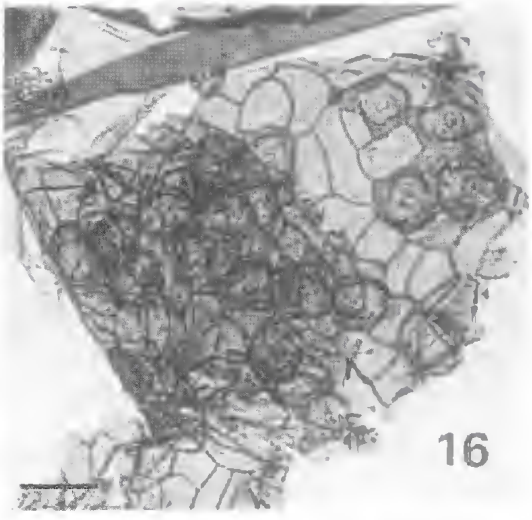
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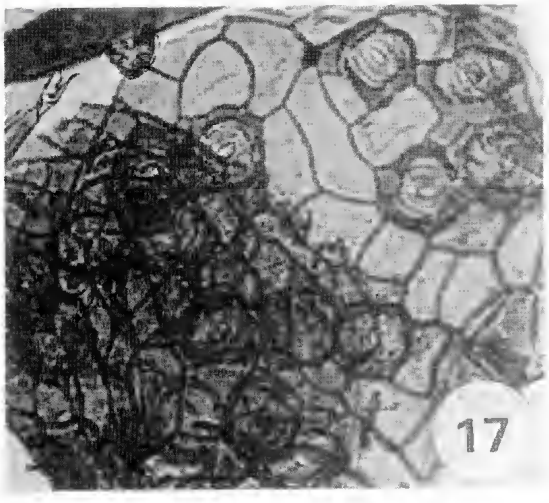
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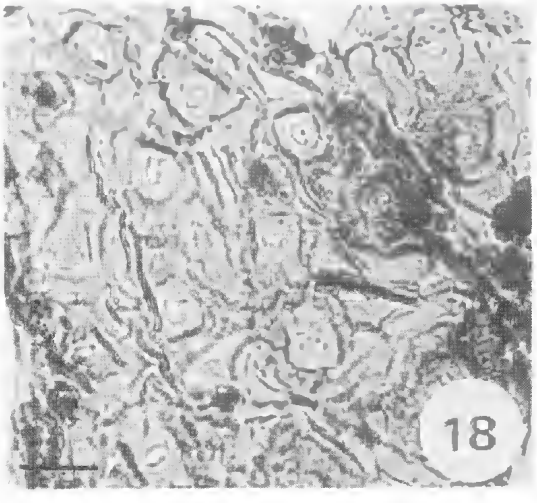
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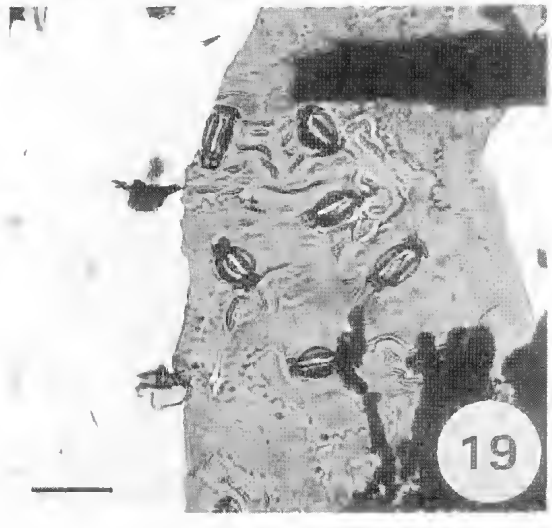
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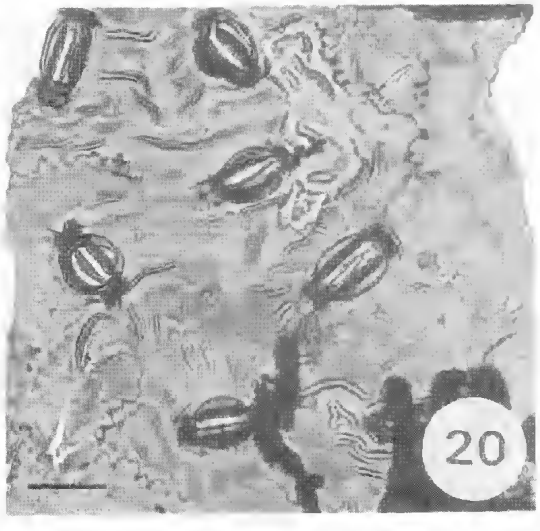
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long axis of the leaf, 40-96 μm long, 12-36 μm wide. Anticlinal wall irregularly thickened, beaded to buttressed. Periclinal wall irregularly thickened, strongly striate to reticulate. Stomata in distinct unisenate rows, oriented parallel to the long axis of the leaf, 92-144 μm long, 24-32 μm wide. Rows 2-6 cells apart. Stomatal arrangement paratetracytic. Subsidiary cells four, lateral subsidiary cells reniform. Anticlinal wall irregularly thickened, smooth to buttressed. Periclinal wall irregularly thickened, smooth to reticulate. Polar subsidiary cells square to rectangular. Anticlinal wall irregularly thickened, smooth to buttressed. Periclinal wall irregularly thickened, reticulate. Polar subsidiary cells may be shared. Florin ring prominent.

Affinity: The parataxon is identical to cuticle described by Greenwood (1987) for the Anglesea fossil species *Podocarpus platyphyllum* (Podocarpaceae). The distinctive beading of the anticlinal walls and striation of the periclinal walls of the epidermal cells are diagnostic of the species. Parataxon No. ABP 002 is therefore identified as *Podocarpus* aff. *P. platyphyllum*.

Cuticle Parataxon No. LC 001
FIGS 12-13

Stomatiferous surface only. Abaxial epidermal cells rounded to undulate (3), becoming elongate over veins, 12-36μm long, 8-20μm wide. Anticlinal wall thin, smooth. Periclinal wall thin, smooth. Stomata randomly oriented, uniform distribution, 20-28μm long, 20-24μm wide, S.I. 11.4. Stomatal arrangement anisocytic to staurocytic. Guard cells not sunken, poral thickening, T-shaped thickening, polar rods present. Outer stomatal ledge prominent, narrow. Subsidiary cells 3-5. Anticlinal wall thin, smooth. Periclinal wall thin, smooth. Hydathodes rare, over veins, dimensions 32μm long, 24μm wide. Oil gland lid cells rare, isodiametric, 32μm in diameter, constricted at sinus. Sinus undulate (single undulation), dark-staining circular region of thickened cuticle centres on sinus. Lid cell surrounded by a cyclocytic arrangement of six modified epidermal cells.

Affinity: The oil gland lid cells and general stomatal morphology (Rowett 1991) confirm affinity of the cuticle parataxon to Myrtaceae.

Cuticle Parataxon No. LC 004
FIGS 14-15

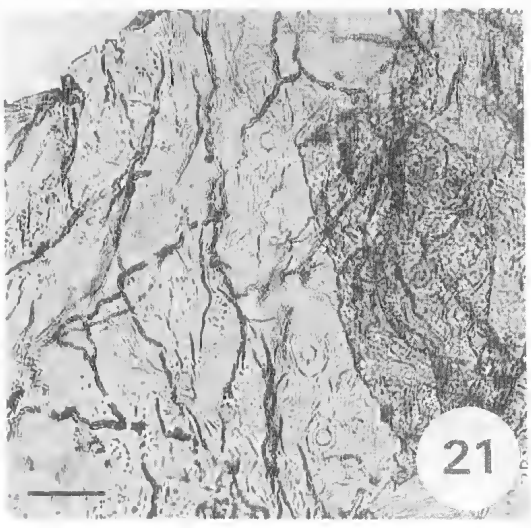
Stomatiferous surface only. Abaxial epidermal cells undulate (3), becoming elongate over veins, 28-40μm long, 16-32μm wide. Anticlinal wall thin, smooth. Periclinal wall irregularly thickened, smooth to finely granulate. Stomata randomly oriented, uniform distribution within well defined areoles, 16-24μm long, 12-16μm wide. Stomatal arrangement brachyparacytic. Guard cells sunken. 3-5 dark-staining, staurocytically arranged epidermal cells surround stomatal apparatus. Raised cuticular folds that encircle and over-arch stomata may be present. Outer stomatal ledge prominent, delicate, narrow. Peristomal rim may be present. Subsidiary cells two, inconspicuous. Anticlinal wall thin, smooth. Periclinal wall irregularly thickened, smooth to granulate. Trichome bases common, over veins, poral, heavily cutinised pore, 4-6 scarcely modified epidermal cells surround pore.

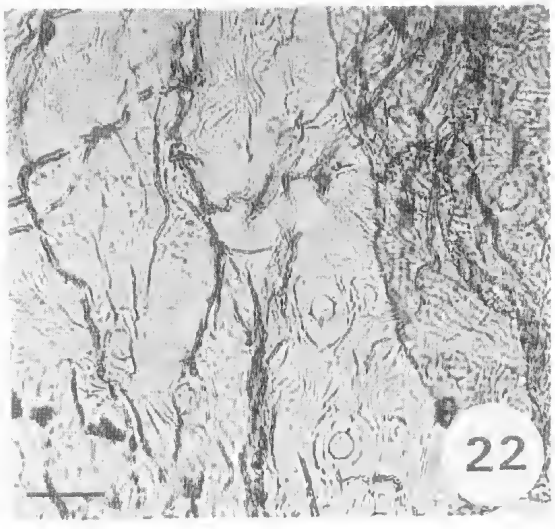
Affinity: The parataxon is assigned to the Proteaceae on the basis of the brachyparacytic stomatal arrangement (Cookson & Pike 1950; Blackburn 1981). The rather inconspicuous, small subsidiary cells encircled by a staurocytic ring of dark-staining epidermal cells, stomatal density and sunken stomata indicate an affinity to *Banksieaephyllum fastigatum* (Cookson & Duigan 1950), i.e. *Banksieaephyllum* aff. *B. fastigatum*.

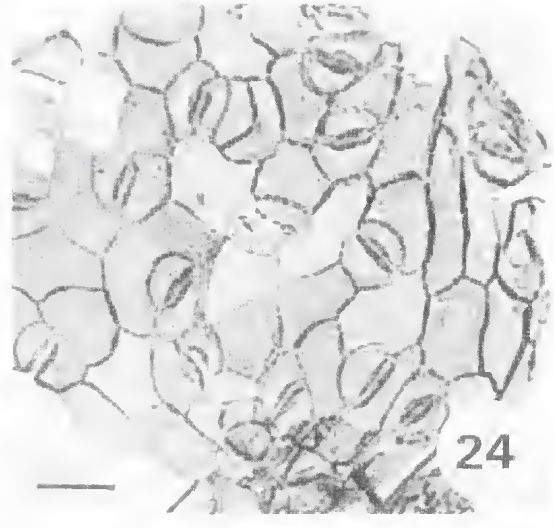
Cuticle Parataxon No. LC 012
FIGS 16-17

Hypostomatic. Adaxial epidermal cells undulate to sinuous (3-4), becoming elongate over veins, 20-44μm long, 16-40μm wide. Anticlinal wall thin, smooth. Periclinal wall thin, smooth.

Figs 15-20. 15, Parataxon No. LC 004, *Banksieaephyllum* aff. *B. fastigatum*, Proteaceae. Shows prominent guard cells, subsidiary cells are generally inconspicuous. Scale 1 cm = 56 μm. 16, Parataxon No. LC 012, *Banksieaephyllum* aff. *B. obovatum*, Proteaceae. Shows small clusters of raised stomates and simple, poral trichome bases scattered amongst stomates. Scale 1 cm = 44 μm. 17, Parataxon No. LC 012, *Banksieaephyllum* aff. *B. obovatum*, Proteaceae. Shows narrow light areas immediately inside dark-staining surrounding cells indicating the position of inconspicuous subsidiary cells. Scale 1 cm = 32 μm. 18, Parataxon No. LC 013, *Banksieaephyllum* aff. ?*B. obovatum*, Proteaceae. Shows raised paracytic stomates and scattered simple, poral trichome bases but the absence of dark-staining surrounding cells makes this indentification tentative. Scale 1 cm = 33 μm. 19, Parataxon No. ABD 002, *Pterostoma* aff. ?*P. zamioides*, Zamiaceae. Shows prominent cuticular ridges over the anticlinal wall of sinuous epidermal cells and heavily cutinised stomates grouped in loosely defined bands. Scale 1 cm = 100 μm. 20, Parataxon No. ABD 002, *Pterostoma* aff. ?*P. zamioides*, Zamiaceae. Shows "bon-bon"-like appearance of the prominent outer stomatal ledge. Note irregular distribution and patterning of cuticular ridges on epidermal cells. Scale 1 cm = 53 μm.







Figs 21-24. 21, Parataxon No. ADB 005. Elaeocarpaceae. Shows high degree of ornamentation (fine striations) that characterises this parataxon. Scale 1 cm = 60 μm. 22, Parataxon No. ABD 005. Elaeocarpaceae. Shows guard cells without ornamentation, other than a fine apiculate outer stomatal ledge. Scale 1 cm = 30 μm. 23, Parataxon No. AG 010. Lauraceae. Shows random arrangement of stomates. Scale 1 cm = 40 μm. 24, Parataxon No. AG 010. Lauraceae. Shows paracytic stomates, highlighting the prominent, narrow outer stomatal ledge, and absence of a guard/subsidiary cell wall, all of which are common features of the family. Scale 1 cm = 30 μm.

Abaxial epidermal cells rounded to undulate (3), becoming elongate over veins, 24 - 44μm long, 12-32μm wide. Areoles well-defined. Anticlinal wall thin, smooth. Periclinal wall thin, smooth. Stomata randomly oriented, uniform distribution, 18-20μm long, 14-20μm wide. Stomatal arrangement brachyparacytic. Guard cells not sunken to very slightly raised. Outer stomatal ledge prominent, narrow. Subsidiary cells two, 4-5 dark-staining staurocytically arranged epidermal cells surround stomatal apparatus. Anticlinal wall irregularly thickened, smooth to beaded. Periclinal wall granulate. Trichome bases common, over veins, poral, some thickening around pore, up to six surrounding cells. Trichomes simple, unicellular, acute apex. Small poral trichomes, common within areoles, four radially arranged surrounding cells.

Affinity: The cuticle parataxon has been assigned to the Proteaceae on the basis of the brachyparacytic stomatal arrangement. The rather inconspicuous, small subsidiary cells encircled by a staurocytic ring of dark-staining epidermal cells, stomatal density and raised

stomata indicate an affinity to *Banksieaephyllum obovatum* (Cookson & Duigan 1950), i.e. *Banksieaephyllum* aff. *B. obovatum*. The feature that distinguishes this fossil species from the related *B. fastigatum* is the superficial position of the stomata, i.e. they are slightly raised.

Cuticle Parataxon No. ABD 002
FIGS 19-20

Hypostomatic. Adaxial epidermal cells sinuous (8), becoming elongate over veins, 40-72μm long, 32-44μm wide. Anticlinal wall irregularly thickened, smooth to beaded to buttressed. Periclinal wall irregularly thickened, striate to reticulate. Striations follow cell outline. The cuticular ornamentation may obscure cell outline.

Abaxial epidermal cells sinuous (6), becoming elongate over veins, 44-80μm long, 20-40μm wide. Anticlinal wall irregularly thickened, thin, beaded. Beading may appear slightly raised. Periclinal wall irregularly thickened, granulate to striate, reticulate. Stomata randomly oriented, arranged in broad bands between veins. S.I. 27.3. Stomatal arrangement haplocheilic. Guard cells sunken. Subsidiary cells 4-5. Anticlinal wall irregularly thickened, beaded. Periclinal wall irregularly thickened, with prominent striation in radiating pattern. Short cuticular folds common over the entire stomatal region, often associated with the stomata. Outer stomatal ledge prominent, raised over lateral subsidiary cells narrows to produce thin arcs over polar subsidiary cells. Gives outer stomatal ledge a "bon-bon"-like appearance. Often absent from polar subsidiary cells.

Affinity: The cuticle has been assigned to extinct *Pterostoma* (Hill 1980) of the Zamiaceae due to sinuous epidermal cells, cuticular ridges/folds on the abaxial surface and a prominent and distinctive stomatal ledge ("bon-bon"-like appearance). The apparent regular venation pattern of the Lochiel specimens suggests a possible affinity to *?P. zamiotdes*.

Cuticle Parataxon No. ABD 005
FIGS 21-22

Stomatiferous surface only. Abaxial epidermal cells rounded to undulate, becoming elongate over veins, 16-28μm long, 8-20μm wide. Anticlinal wall thin, smooth. Periclinal wall irregularly thickened, smooth to striate. Striations obscure most cell detail. Stomata randomly oriented, uniform distribution, 16-24μm long, 16-20μm wide. S.I. 13.5. Stomatal arrangement staurocytic? Guard cells not sunken, polar rods present. Subsidiary cells 4-6? Outer stomatal ledge evident, narrow. T-shaped thickening occasionally present. Hydathodes rare, over veins, 36-44μm long, 20-28μm wide. Striations radiate out from hydathode.

Affinity: The cuticle parataxon is assigned to the Elaeocarpaceae on the basis hydathodes and what appears to be a staurocytic stomatal arrangement.

Cuticle Parataxon No. AG 010
FIGS 23-24

Stomatiferous surface only. Abaxial epidermal cells angular to rounded, becoming elongate over veins, 24-44μm long, 12-28μm wide. Anticlinal wall thin, smooth. Periclinal wall thin, smooth. Stomata 20-24μm long, 20-36μm wide, randomly oriented, uniform distribution. S.I. 11.1. Stomatal arrangement paracytic. Guard cells slightly sunken. Guard cell/subsidiary cell wall absent. Cuticular scales prominent, narrow. Subsidiary cells two. Anticlinal wall thin, smooth. Periclinal wall thin, smooth.

Affinity: The cuticle type is assigned to the Lauraceae due to the paracytic stomates and inconspicuous, sunken guard cells.

Floristic Comparison of Samples

The older lignite flora comprising 38 dispersed cuticle parataxa is characterised by an abundance of Araucariaceae, Podocarpaceae, Myrtaceae and Proteaceae cuticles and minor occurrences (<1%) of Casuarinaceae, Elaeocarpaceae, Lauraceae and Zamiaceae cuticles which easily distinguishes it from the younger monospecific flora.

The floristic difference is also reflected in the two lithotypes. The lignite of the older sample (Facies Ia) is defined as an earthy textured coal containing more than 40% relatively ungelified woody material (Springbett 1980 pers. comm.). Facies IIa is a darker fibrous, lignite consisting of gelified twigs (Fig. 2).

Correlation between flora and lithotype indicates that the two floras were deposited in different sedimentary environments, and as the Kooliata Coal Zone consists of peatswamp and lacustrine sand and silt cycles (Kremor & Springbett 1992) the changes in the sedimentary environments are most likely due to fluctuations in water level. The degree of gelification also gives an indication of changes in water levels (Springbett pers. comm.); high degree of gelification — low water level and vice versa.

Comparison with Other Australian Tertiary Deposits

The dispersed cuticle floras of the Lochiel deposit includes parataxa that occur in a number of other

Australian Tertiary deposits. *Banksieaephyllum* aff. *B. laeve*, the principal parataxon of the Sedan lignites is well represented at Lochiel. This expands the known distribution of the species and establishes a floristic link between the Northern St Vincent Basin and Latrobe Valley, from where the type species was originally described. This association is further strengthened by the presence of *Banksieaephyllum* aff. *B. fastigatum* and *Banksieaephyllum* aff. ? *B. obovatum* (Cookson & Duigan 1950) both reported outside the Latrobe Valley for the first time. *Banksieaephyllum obovatum* has also been identified in the Miocene coals at Morwell where it occurs in low frequencies in the medium light coloured coals, the colour values 90-116 (State Electricity Commission of Victoria Coal colour classification scheme, Blackburn 1985[1]). All three cuticle types have affinities to the modern genus *Banksia* (Blackburn 1985[1]; Hill & Christophel 1988).

Parataxon No. LC 011 in both the Lochiel and Sedan deposits has an affinity to the Myrtaceae. It is a minor component in the floras of both localities but is most abundant at Lochiel. The cuticle type has also been identified from the Middle Eocene Maslin Bay sediments.

The occurrence of *Pterostoma* aff. *?P. zamioides* (parataxon No. ABD 002) at Lochiel is significant in that it represents the first report of *Pterostoma* specimens outside of south-eastern Australia and Tasmania. *Pterostoma* is reported from a number of Tertiary localities, including Anglesea (Eocene, *P. zamioides* Hill 1980), Nerriga (Eocene, *P. anastomosans* Hill 1980) Cethana (Oligocene, Carpenter 1991) and Buckland (Eocene, Carpenter 1991) and has a known stratigraphic range from the Cretaceous to Early Oligocene (Hill pers. comm.). With such a extensive age range for *Pterostoma* parataxon No. ABD 002 is of little biostratigraphic significance.

Similarly, parataxon No. LC 015 with an affinity to *Dacrycarpus*, is of little biostratigraphic importance. *Dacrycarpus* is the most common podocarp genus in Tertiary sediments in south-eastern Australia which is known from numerous deposits ranging in age from Eocene to Oligocene-Miocene (Anglesea, Vegetable Creek, Yallourn, Bacchus Marsh in mainland Australia and Regatta Point, Loch Aver and Cethana in Tasmania) (Hill & Carpenter 1991). Therefore cuticles assigned to *Dacrycarpus* are unsuitable as biostratigraphic indicators. However, indentification of *Dacrycarpus* cuticles at Lochiel does expand our knowledge of the distribution of the genus during the Late Eocene.

There are a number of Anglesea parataxa present in the Lochiel flora, including No. ABP 001 (*Podocarpus aff. P. platyphyllum*), all representatives of the Elaeocarpaceae and Lauraceae and several of the unknown cuticle types.

In conclusion, analysis of the dispersed cuticle floras of Facies Ia and IIa, of the Lochiel lignite show that two distinct floras exist, i.e. the diverse, Araucariaceae-dominated flora of the older ungelified, woody lignite and the monospecific flora (parataxon No. AW 007) of the younger dark, gelified lignite. The lithotype and floral differences between lignites are most likely due to fluctuations in the hydrological cycle, changing from a lacustrine to peatswamp environment. These differences may prove useful in intra-basin correlation.

The dispersed cuticle composition of the Lochiel lignites provides valuable information on the distribution of a number of Tertiary plant taxa, including *Agathis*, *Banksieaephyllum* aff. *B. laeve*, *Banksieaephyllum* aff. *B. fastigatum* and *Banksieaephyllum* aff. *?B. obovatum*, *Dacrycarpus*, *Gymnostoma*, *Podocarpus platyphyllum* and *Pterostoma*. The presence of the three Latrobe Valley *Banksieaephyllum* species provides a interesting floristic link between the deposits and may be of some biostratigraphic significance. Rowett (1991) discussed this point in relation to *Banksieaephyllum* aff. *B. laeve* at Sedan and concluded that its occurrence could either imply a younger age for the deposit or an extended lower limit to the age of the fossil. These comments could apply to the *Banksieaephyllum* cuticle types of Lochiel. However, as the dispersed cuticle flora is without any known Eocene, Oligocene or Miocene indicators little can be concluded regarding the age of the Lochiel lignites in addition to that provided by palynology.

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[1] Blackburn, D. T. (1985) Palaeobotany of the Yallourn and Morwell coal seams. Palaeobotanical Report No. 3. State Electricity Commission of Victoria.

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